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MOVEMENTS, STOCK COMPOSITION, AND ABUNDANCE OF NORTHERN PIKE IN MINTO FLATS DURING 1987 and 1988[1]

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ABSTRACT

Northern pike *Esox lucius* were sampled in 1987 and 1988 with modified hoop trap weirs, gill nets, electrofishing, seines, and hook and line. Radio telemetry identified concentrations of overwintering northern pike in Area I and Area III of Minto Flats. Tag and recapture data and telemetry data provide evidence that there are two geographic sub-populations in Minto Flats. In 1987, 51 percent of the northern pike sampled were age 6 and older, while in 1988 35 percent were age 6 and older, with age 3 the most abundant cohort. Length frequencies for both 1987 and 1988 showed two distinct modes. Parameters for estimation of an age-length relationship were not obtained due to insufficient captures of larger-sized fish.

Estimates of abundance from mark-recapture experiments were 23,293 and 26,116 for fish over 299 millimeters in fork length in 1987 and 1988, respectively. Northern pike densities in Minto Flats in both 1987 and 1988 were in the low end of the range of densities reported for other Alaskan populations as well as non-Alaskan populations. The combined sport and subsistance harvest exceeded what is thought to be maximum sustainable yield in 1987.

KEY WORDS: Northern Pike, *Esox lucius*, Minto Flats Alaska, radio telemetry, mixing rates, age composition, Relative Stock Density, abundance, mark-recapture.

INTRODUCTION

Next to Arctic grayling *Thymallus arcticus*, northern pike *Esox lucius* are the most sought-after indigenous sport fish species in interior Alaska (Holmes 1987). Harvests of northern pike in interior Alaska averaged about 14,500 fish between 1977 and 1984 with more recent harvests at about 15,500 fish (Mills 1987). Between 75% and 90% of the harvest of northern pike in Alaska on an annual basis occurs in interior Alaska. Tanana River drainage waters account for about 65% of the statewide sport harvest (Figure 1). Minto Flats, George Lake, Harding Lake, and Volkmar Lake are the most popular northern pike sport fishing areas in the Tanana River drainage. Minto Flats has had the largest sport fishery for northern pike in terms of effort and harvest in 10 of the previous 12 years (Mills 1979-1988). From 1981 to 1984 the average sport harvest in Minto Flats was 2,279 northern pike.

In addition to the sport fishery there is a subsistence fishery by the residents of Minto Village. The subsistence harvest occurs primarily in the spring and fall. In 1983 the estimated subsistence harvest was 3,003 northern pike (Andrews 1988). In 1985 a new sport fishery developed on a concentration of overwintering northern pike in the middle part of the Chatanika River. This fishery increased the harvest in the sport fishery to 4,665 northern pike in 1985 and 4,903 northern pike in 1986. Reports from anglers and a limited creel survey (Holmes and Burkholder 1988) indicated that a large portion of the harvest from this new fishery were prespawning females. Concern that increasing harvests could be exceeding sustainable yield prompted the Department to close the winter sport fishery for northern pike by emergency order in January 1987. In the spring of 1988, the fishing season was shortened to 1 June through 14 October and the bag limit was reduced to five northern pike a day with one fish over 30 inches. The Department also initiated a research program in 1987 to determine if present management practices are sufficient to maintain this important sport fishery.

This report summarizes research conducted in 1987 and 1988 concerning northern pike movements, stock composition, and abundance in Minto Flats.

Study Area

Minto Flats is a 200,000 ha area of marsh and lakes connected by numerous sloughs and four major rivers: the Tolovana, Chatanika, and Tatalina Rivers, and Goldstream Creek (Figure 2). The rivers are slow-flowing and meandering. The lakes are shallow and contain large areas of dense aquatic vegetation. Holmes and Burkholder (1988) estimated useable habitat for northern pike in Minto Flats consists of 6,000 ha. Minto Flats can be reached by float-equipped aircraft, by road to Minto Village, or by road from Murphy Dome to the middle Chatanika River.

Study Objectives

The goal of this research program is the stock assessment of northern pike in Minto Flats along with investigations concerning the life history of the population relevant to the management of the sport fishery.

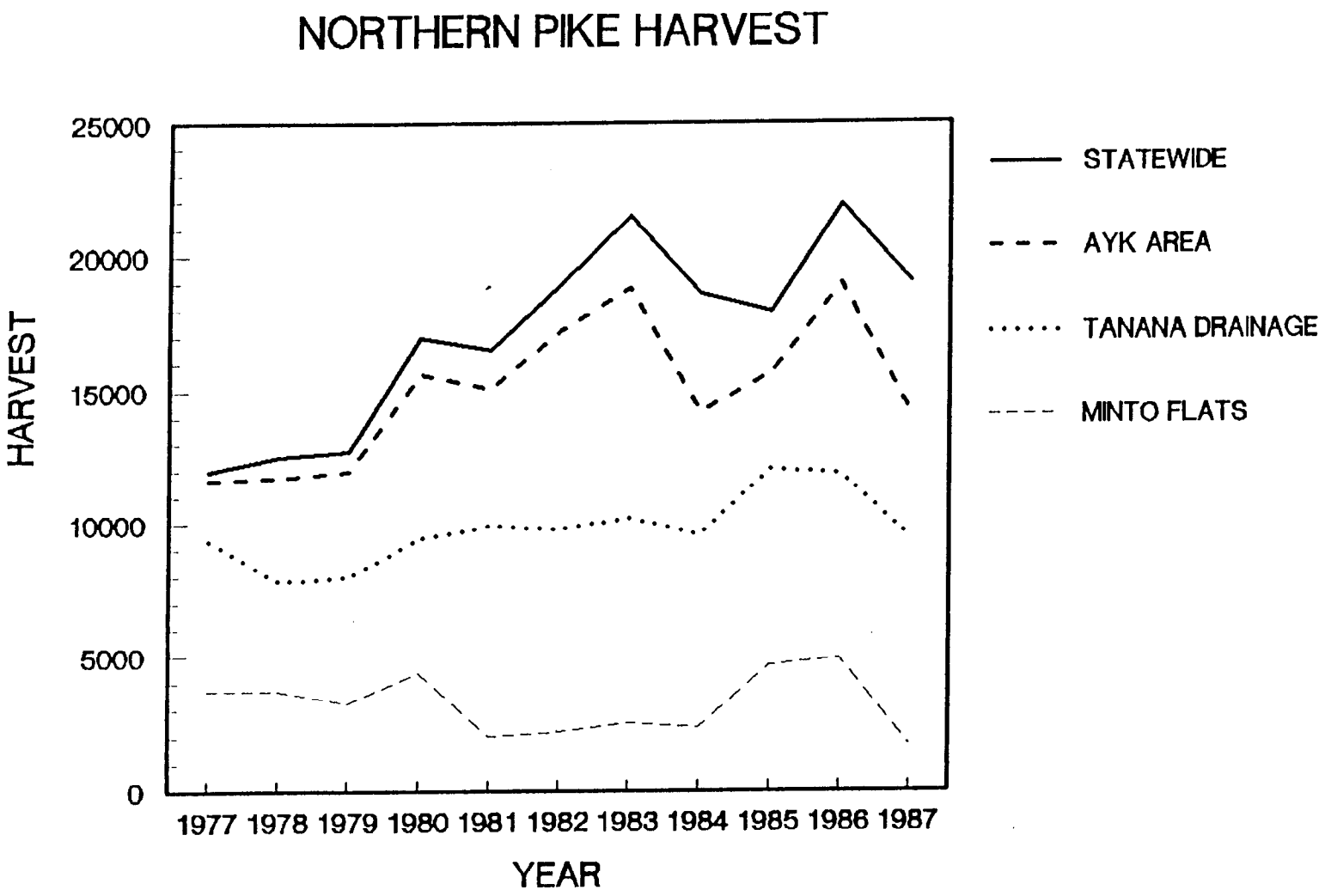

Figure 1. Estimated harvest of northern pike in Alaska, the Arctic-Yukon-Kuskokwim Area (AYK), the Tanana drainage, and Minto Flats, 1977-1987 (Mills 1978-1988).

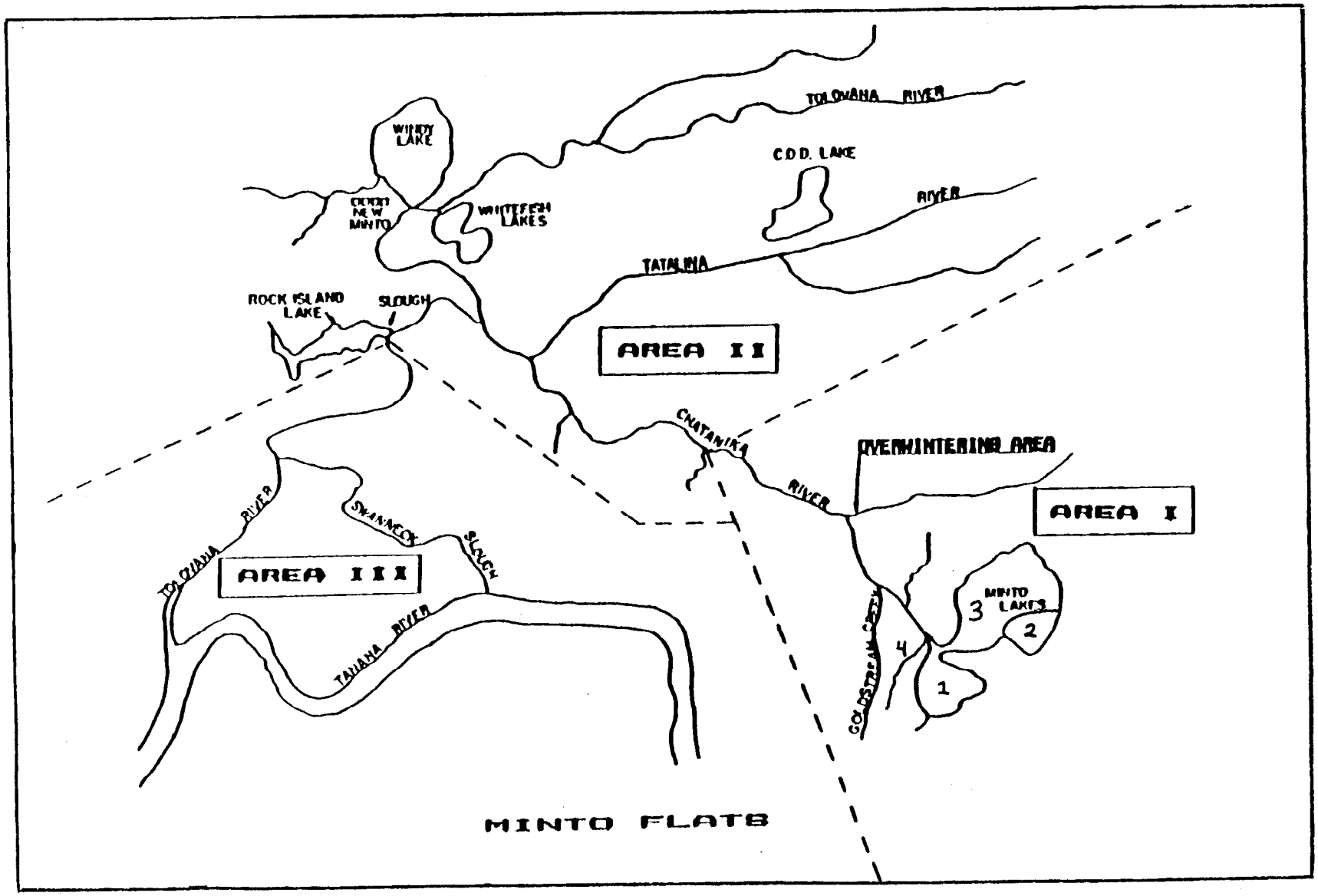

Figure 2. Minto Flats drainage and major sampling areas.

Specific objectives of the 1988 research program were to:

1. estimate the mixing rates of northern pike among their major spawning, summer-rearing and overwintering areas of Minto Flats;

2. estimate the sex and age composition of the northern pike population in Minto Flats;

3. estimate the mean length of the population in Minto Flats; and,

4. estimate the parameters in the age-length relationship for populations of northern pike in Minto Flats.

In addition to these specific objectives population abundance was estimated for fall of 1987 and spring of 1988.

METHODS

There were two discrete sampling events (12 May to 30 June and 14 September to 3 October) during 1988. Sampling gear included: fyke nets, hoop traps with wings and leads joined together to form weirs, gill nets, and pulsed D.C. boat-mounted electrofishing systems. Captured, northern pike were measured to the nearest millimeter of fork length (FL). The external characteristics described by Casselman (1974) were used to identify sex for all northern pike in 1987. Because recapture information revealed that sex determination by external characteristics was unreliable, sex was recorded only for northern pike extruding sexual products in 1988. The left pectoral fin was clipped on each fish over 299 mm in length and each fish was tagged with a Floy FD-68 internal anchor tag. The capture location of each fish was recorded as one of 23 subareas of Minto Flats (Table 1). These subareas were grouped into three major areas (Figure 2; Table 1): (I) the upper Chatanika River, Goldstream Creek, and Big Minto Lakes complex; (II) the lower Chatanika River, Tatalina River, and upper Tolovana River drainages; and (III) the lower Tolovana River and Swanneck Slough drainages.

A scale sample was removed from each fish for estimating age. Previous analysis (Peckham and Bernard 1987) indicates estimated ages from scales, sagittal otoliths, and cliethra are similar. Scales were stored in coin envelopes and were later removed for cleaning and mounting on gum cards. Gum cards were used to make impressions on 20 mil acetate using a Carver press at 137,895 kilo Pascals (20,000 psi) heated to 93^0 C for 30 seconds. Annuli were counted along their dorsal radius using a Micron 770 Microfiche reader. Scales, cleithra, and vertebrae were taken from northern pike killed during sampling.

Mixing

Relative mixing rates for northern pike between the three major areas were calculated for floy tag recaptures and radio telemetry tracking (Holmes and Burkholder 1988) for the following seasonal periods:

Table 1. Sampling areas in Minto Flats.

Area No.	Section Number	Location
1	1	Big Minto Lake No. 1
1	2	Big Minto Lake No. 2
1	3	Big Minto Lake No. 3
1	4	Big Minto Lake No. 4
1	5	Goldstream Creek (upstream of Caches)
1	6	Goldstream Creek (Caches to Chatanika)
1	7	Chatanika (upstream of access road)
1	8	Chatanika (Goldstream to access road)
1	9a	Chatanika (Birch Cr. Sl. to Goldstream)
2	9b	Chatanika (Birch Cr. Sl. to Tolovana R.)
2	10	Tatalina (Chatanika to South Fork)
2	11	Main Tatalina (upstream of South Fork)
2	12	South Fork of Tatalina
2	13	Tolovana (Chatanika to Minto Village)
2	14	Tolovana (upstream of Minto Village)
2	15	Lakes south of Tolovana
2	16	Lakes north of Minto
2	17	Lakes northwest of Minto
2	19	Rock Island Slough
3	18	Tolovana (Chatanika to Swanneck Slough)
3	20	Tolovana (Swanneck to Tanana)
3	21	Swanneck Slough
3	22	Grassy Slough
3	23	Tanana River

1. within a season (spring-spring, fall-fall, and winter-winter);
2. across seasons (spring-fall, fall-winter fall-spring); and
3. across years (spring 1987-spring 1988 and fall 1987-fall 1988).

Relative mixing rates of northern pike were determined using multinomial proportions based on all northern pike recaptures. The marginal proportions and associated variances in this multinomial distribution were:

$$(1) \quad \hat{p}_{ij} = \frac{r_{ij}}{r_{i.}};$$

and,

$$(2) \quad V[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{r_{i.} - 1}$$

where:

$r_{i.}$ = the number of northern pike marked in area i;

r_{ij} = the number of northern pike marked in area i and recaptured in area j; and,

p_{ij} = the relative mixing rate of northern pike released in area i and recaptured in area j.

Composition Estimation

In 1987, no size-selectivity occurred in the first event; therefore, the first event was chosen for age and length composition estimates. In 1988, size-selectivity occurred in the first event for both the 300-599 mm and the > 599 mm abundance estimates; therefore, the second sampling event was used for age and length composition estimates.

After a review of Gabelhouse (1984), categories for estimates of Relative Stock Density were defined as follows: "stock" size, 300 to 524 mm (FL); "quality" size, 525 to 654 mm; "preferred" size, 655 to 859 mm; "memorable" size, 860 to 1079 mm; and "trophy" size, 1,080 mm and longer.

The proportions of the population corresponding to each age and size category were estimated with the following formulas (Cochran 1977):

$$(3) \quad \hat{p}_j = \frac{n_j}{n};$$

and,

$$(4)\quad \hat{V}[\hat{p}_j] = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1};$$

where:

n_j = the number in the sample from category j;

n = the sample size; and,

p_j = the estimated fraction of the population that is made up of category j.

Abundance of northern pike for length and age categories was estimated as follows:

$$(5)\quad \hat{N}_j = \hat{p}_j(\hat{N});$$

where:

$\hat{N}_j$ = estimated number of northern pike > 299 mm FL in category j;

$\hat{p}_j$ = estimated proportion of northern pike 300 mm and longer in category j; and,

$\hat{N}$ = estimated abundance of all northern pike 300 mm and longer.

Variances for Equation 5 are from Goodman (1960):

$$(6)\quad \hat{V}[\hat{N}_i] = (\hat{p}_i^2\hat{V}[\hat{N}])+(\hat{N}^2\hat{V}[\hat{p}_i])-(\hat{V}[\hat{p}_i]\hat{V}[\hat{N}]).$$

When gear bias was detected, the proportion of the population corresponding to each age and length category were estimated with formula (5) and the approximate variance was calculated with formula (6) (from the Delta method, Seber 1982):

$$(7)\quad \hat{P}_j = \frac{\Sigma\, \hat{P}_{ij}\,\hat{N}_i}{\Sigma\, N_i}\ ;\ \text{and,}$$

$$(8)\quad \hat{V}[\hat{P}_j] = \Sigma\, \hat{V}[\hat{P}_{ij}] \left\{ \frac{\hat{N}_i}{N} \right\}^2 + \frac{\Sigma\, \hat{V}[\hat{N}_i]\ (\hat{P}_{ij} - \hat{P}_j)^2}{N^2}$$

where:

P_{ij} = the estimated fraction of the population that is made up of category j in strata i; and,

N_i = the estimated population abundance in strata i.

The estimated abundance of category j in the population (N_j) is:

$$(9)\quad \hat{N}_j = \Sigma\, \hat{P}_{ij}\, \hat{N}_i$$

The variance for N_j is a sum of the exact variance of a product from Goodman (1960):

$$(10)\quad V[\hat{N}_j] = \Sigma\, (V[\hat{P}_{ij}]\hat{N}_i^2 + V[\hat{N}_i]\hat{P}_{ij}^2 - V[\hat{P}_{ij}]V[\hat{N}_i])$$

Mean length of the population in 1987 and 1988 was calculated as the arithmetic mean of all fish lengths. Variances were calculated with the squared deviations from the mean (standard variance formula). Standard errors of the mean (SE) were calculated as the square root of the variance divided by the sample size.

Growth Parameters

Growth characteristics were estimated with length-at-age data using the von Bertalanffy growth model (Ricker 1975).

Abundance Estimate 1987

The marking event took place from 1 August through 13 October 1987 and the recapture event occurred from 12 May to 30 June 1988. The Chapman modification of a single-mark Petersen estimator was selected (Chapman 1951) to estimate the population abundance of northern pike larger than 299 mm FL. Population abundance and the approximate variance of this estimate were calculated with the following formulas (Seber 1982):

$$(11)\quad \hat{N} = \frac{(C+1)(M+1)}{(R+1)} - 1;$$

and,

$$(12)\quad V[\hat{N}] = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)};$$

where:

$\hat{N}$ = abundance of northern pike > 299 mm FL:

M = number marked during the first period;

C = number captured during the second period; and,

R = number captured during the second period with marks from the first period.

Abundance Estimate 1988

The marking event took place from 12 May to 30 June and the recapture event occurred between 12 and 30 September 1988. Length distribution of marked and unmarked fish in the recapture event were significantly different ($D = 0.28$, $P < 0.01$), necessitating two separate abundance estimates: one for fish 300-599 mm and one for fish > 599 mm (growth recruitment became negligible at about 600 mm, after a test formulated by Robson and Flick, 1965; Appendix Table 1). The abundance of northern pike 300-599 mm was calculated using a variation of the Robson and Flick (1965) model:

$$(13) \quad \hat{N}_s = (m + 1)(\bar{u} + 1) - 1$$

where:

$\hat{N}_s$ = estimated abundance of fish 300-599 mm FL, where s denotes small fish;

m = number of marked fish from the first sampling event that are 300-599 mm FL; and,

$\bar{u}$ = frequency of unmarked fish averaged over the cells formed by the marked fish > 599 mm FL.

The variation was used because of gear selectivity and its coincidence with growth recruitment.

The variance of $\hat{N}_s$ is taken from Seber (1982):

$$(14) \quad V(\hat{N}_s) = (m + 1)^2 V[\bar{u}].$$

The variance of u is calculated using standard normal procedures to find the variance of a mean over the ui where i is from r to M.

Abundance Estimate Conditions

Conditions for the accurate use of the Petersen mark-recapture estimator include (Seber 1982):

1. a closed population (no change in the number of fish in the population during the experiment);

2. all northern pike have the same probability of capture in the marking sample or in the recapture sample, or marked and unmarked northern pike mix completely between marking and recapture events;

3. marking of northern pike does not affect their probability of capture in the recapture sample;

4. northern pike do not lose their mark between the marking and recapture events; and,

5. all marked northern pike are reported when recovered in the recapture sample.

Conditions 1-3 were examined using Kolmogorov-Smirnov (KS) Two Sample and chi-square tests.

Growth recruitment was examined to ascertain compliance with condition 1. Size selectivity of sampling gear, and mixing and equal probabilities of capture during the first event, were examined to ascertain compliance with condition 2. Differential mortality between gear types (electrofishing, hook and line, traps, and gill nets) was examined to determine compliance with condition 3. Condition 4 was not tested. All marked northern pike in the recapture sample were noted.

RESULTS

In the fall of 1987, 960 northern pike were captured throughout Minto Flats. More than half of these fish were captured by electrofishing (57% by electrofishing, 25% in gill nets, 11% by hook and line, and 7% in traps). Of these northern pike, 914 were tagged and released, 31 were mortalities and the remaining fish were released unmarked (< 300 mm or the same fish caught more than once during this sampling period). Out of the 914 marked fish, 366 were used for the mark in the 1987 abundance estimate. Northern pike caught by electrofishing were not used for the 1987 mark.

In the spring of 1988, 1,238 northern pike were captured throughout Minto Flats. Most of these fish were captured in traps (83% in traps, 13% in gill nets, 3% by electrofishing and 1% by seines and hook and line). Of these northern pike, 1,028 were tagged and released (mark for 1988 abundance estimate), 98 (9%) were mortalities and the rest were released unmarked (< 300 mm or the same fish caught more than once during this sampling period). Sixteen were recaptures from the 1987 fall marking event and 1,078 were counted as the catch for the 1987 abundance estimate (> 299 mm and captured only once during this sampling event).

During the fall of 1988, 1,754 northern pike were captured throughout Minto Flats. These fish were captured by electrofishing (71%) and by traps (29%). Of these fish, 1,514 were counted as the catch for the 1988 population

abundance estimate (> 299 mm and caught only once during this sampling event). Fifty-one (3%) northern pike were killed during this sampling event.

The major cause of known sampling mortality of northern pike was fish < 300 mm gilled in trap leads.

Sex determination proved unreliable at the time of sampling.

Mixing

Relative mixing rates between the three major Areas of recaptured northern pike were highest for fish recaptured in the same area as they were marked for each seasonal category (Table 2). The greatest amount of mixing between the three areas occurred across seasons where northern pike marked in Area II were recaptured in Areas I and III at similar rates, 0.19 and 0.16 respectively.

Results from the radio telemetry tracking (Table 3) differed from the Floy tag recaptures. The greatest amount of mixing occurred within a season, where northern pike marked in Area II were recaptured in Areas I, II, and III at a rate of 0.42, 0.39, and 0.19, respectively.

Even though the time periods for the greatest amount of mixing were different for the radio tracked and recaptured northern pike, mixing trends were similar. Northern pike in Area II mixed (left Area II) with fish in Areas I and III during certain time periods, while northern pike in Areas I and III generally stayed in their respective areas. Radio tracking in the fall of 1987 indicated most northern pike left Area II and dispersed evenly to Areas I and III. Sampling conducted in the fall of 1988 supported the result obtained with radio telemetry: that northern pike leave Area II in the fall.

Radio telemetry identified three major overwintering areas: the middle Chatanika River (Area I) Minto Lake outlet and channels (Area I), and the lower Tolovana and Tanana Rivers (Area III). Of the 14 northern pike implanted with transmitters that left Minto Flats to overwinter in the Tanana River, only three were located during the following spring. All three were located within Minto Flats (one in each area). During March of 1988, 20 more northern pike were captured at the middle Chatanika overwintering area, implanted with transmitters and released. Most of these fish (14) stayed in Area I, four went to Area II and one went to Area III (one was never relocated).

Age Composition

Of the 780 northern pike for which ages were determined in 1987, 51% were age 6 or older (Table 4). Ages of northern pike > 299 mm ranged from 2 through 12 years. The most abundant age cohort was age 5. Estimated abundance of age cohorts decreased as age increased from age 5 through age 12.

Of the 1,382 northern pike for which ages were determined in 1988, 35% were age 6 and older (Table 5). Ages of northern pike > 299 mm ranged from 1 through 14 years. The most abundant age cohort was age 3. Estimated abundance of age cohorts decreased as age increased from age 3 through age 14.

Table 2. Relative mixing rates (standard error in parentheses) of northern pike between the three major areas of Minto Flats from floy tag recaptures.

	Area Marked	Area Recaptured I	Area Recaptured II	Area Recaptured III
Within a Season	I	0.99 (0.01)		0.01 (0.01)
	II	0.09 (0.03)	0.84 (0.04)	0.07 (0.03)
	III	0.02 (0.02)	0.10 (0.04)	0.88 (0.04)
Across Seasons	I	0.92 (0.04)	0.05 (0.03)	0.03 (0.02)
	II	0.19 (0.07)	0.65 (0.09)	0.16 (0.07)
	III			1.00
Between Years	I	0.95 (0.04)	0.05 (0.04)	
	II		0.88 (0.07)	0.12 (0.07)
	III			

Table 3. Relative mixing rates (standard error in parentheses) of northern pike between the three major areas of Minto Flats from radio telemetry tracking.

	Area Marked	Area recaptured I	II	III
Within a Season	I	0.99 (0.01)		0.01 (0.01)
	II	0.42 (0.09)	0.39 (0.09)	0.19 (0.07)
	III	0.04 (0.03)	0.02 (0.02)	0.94 (0.03)

	Area Marked	Area Recaptured I	II	III
Across Seasons	I	0.90 (0.03)	0.08 (0.03)	0.02 (0.01)
	II	0.20 (0.20)	0.80 (0.20)	
	III	0.16 (0.09)	0.05 (0.05)	0.79 (0.09)

Table 4. Estimated age composition and estimated abundance by age cohort for northern pike larger than 299 mm in Minto Flats 1987.

Age Class	Sample Size	Estimated Proportion	Estimated SE of Proportion	Estimated Abundance	Estimated SE of Abundance
2	24	0.03	0.01	717	216
3	97	0.12	0.01	2,897	714
4	128	0.16	0.01	3,822	923
5	136	0.17	0.01	4,062	977
6	122	0.16	0.01	3,643	883
7	113	0.14	0.01	3,374	821
8	85	0.11	0.01	2,538	632
9	29	0.04	0.01	866	250
10	30	0.04	0.01	896	257
11	7	0.01	<0.01	209	90
12	9	0.01	<0.01	269	106
Total	780			23,293	

Table 5. Estimated age composition and estimated abundance by age cohort for northern pike larger than 299 mm in Minto Flats 1988.

Age Class	Sample Size	Estimated Proportion	Estimated SE of Proportion	Estimated Abundance	Estimated SE of Abundance
1	31	0.02	<0.01	562	102
2	103	0.07	0.01	1,866	193
3	314	0.22	0.02	5,697	366
4	281	0.20	0.02	5,156	358
5	194	0.15	0.01	3,705	444
6	160	0.12	0.01	3,154	536
7	140	0.11	0.01	2,796	536
8	90	0.07	0.01	1,800	366
9	44	0.03	0.01	879	201
10	15	0.01	<0.01	300	92
11	6	<0.01	<0.01	120	52
12	3	<0.01	<0.01	60	35
13	0	---	---	---	---
14	1	<0.01	<0.01	20	20
Total	1,382			26,115	

Length Distribution

Length frequencies for both 1987 and 1988 showed two distinct modes. Modal lengths of northern pike sampled during 1987 and 1988 differed by 25 mm (Table 6 and Figure 3). Mean length was 597 mm in 1987 and 587 mm in 1988. Relative stock density estimates differed for 1987 and 1988 (Table 7). The proportions of stock, memorable, and trophy categories were higher in 1988 than 1987. The proportions of quality and preferred categories were lower in 1988 than 1987.

Growth Parameters

Parameter estimates for the von Bertalanffy growth equation were not generated. Length frequency plots revealed insufficient capture of larger-sized northern pike, which were needed to assess growth characteristics.

Abundance Estimate 1987

Estimated abundance of northern pike > 299 mm in Minto Flats during the fall of 1987 was 23,293 fish (SE = 5,319). The density of northern pike > 299 mm was estimated to be 3.87 fish per ha.

No demonstrable growth recruitment occurred during the winter ($D = 0.15$, $P = 0.34$), thereby fulfilling condition 1 of the Petersen mark-recapture estimator.

Lengths of fish marked during the first event and recaptured during the second event were not significantly different ($D = 0.30$, $P = 0.11$), indicating there was no size selectivity in the second event. Lengths of all fish captured during the first event were significantly different from lengths of all fish captured during the second event ($D = 0.09$, $P = 0.03$). However, graphical comparison of these length distributions (Figure 4) showed no obvious difference, therefore it was concluded that the significant difference of the Kolmogorov-Smirnov Two-Sample test was due to large sample sizes and that there was no meaningful size selectivity during the first event.

Mixing of pike between major areas of Minto Flats between events was not complete. However, probabilities of capture during the first event were not significantly different ($\chi^2 = 3.28$, $df = 2$, $0.10 < P < 0.25$) thereby fulfilling condition 2.

The proportion of recaptures that were originally caught by electrofishing was significantly less than the proportion of recaptures originally caught by other gear types ($\chi^2 = 8.319$, $df = 1$, $P < 0.005$), while the proportions of the other gear types were not significantly different ($\chi^2 = 0.015$, $df = 2$, $0.990 < P < .995$). Current investigations (Holmes et al. in press) suggest electrofishing may produce a higher mortality among northern pike than other gear types. Since both the chi-square tests and the ancillary information (Holmes et al. in press) provide evidence of higher mortality by electrofishing, all northern pike captured during the first event by electrofishing were excluded from the abundance calculation.

Table 6. Length frequency of northern pike in Minto Flats during the first sampling event in 1987 and the second sampling event in 1988.

Length Class (mm FL)	1987		1988	
	Number	Percent	Number	Percent
300-324	10	1.18	21	1.39
325-349	9	1.06	7	0.46
350-374	20	2.35	24	1.59
375-399	26	3.06	54	3.57
400-424	23	2.70	85	5.61
425-449	39	4.58	76	5.02
450-474	41	4.82	103	6.80
475-499	52	6.11	118	7.79
500-524	56	6.58	138	9.11
525-549	63	7.40	112	7.40
550-574	52	6.11	79	5.22
575-599	34	4.00	68	4.50
600-624	48	5.64	54	3.57
625-649	52	6.11	49	3.27
650-674	62	7.29	63	4.16
675-699	57	6.70	81	5.35
700-724	50	5.88	73	4.82
725-749	34	4.00	69	4.56
750-774	38	4.47	59	3.90
775-799	29	3.41	34	2.25
800-824	25	2.94	32	2.11
825-849	6	0.71	40	2.64
850-874	10	1.18	32	2.11
875-899	5	0.59	13	0.86
900-924	7	0.82	15	0.99
925-949	1	0.12	7	0.46
950-974	2	0.24	4	0.26
975-999			1	0.07
1000-1024			1	0.07
1025-1049			1	0.07
1050-1074			0	0.00
1075-1099			0	0.00
1100-1024			0	0.00
1125-1049			1	0.07
Totals	851	100.00	1,514	100.00

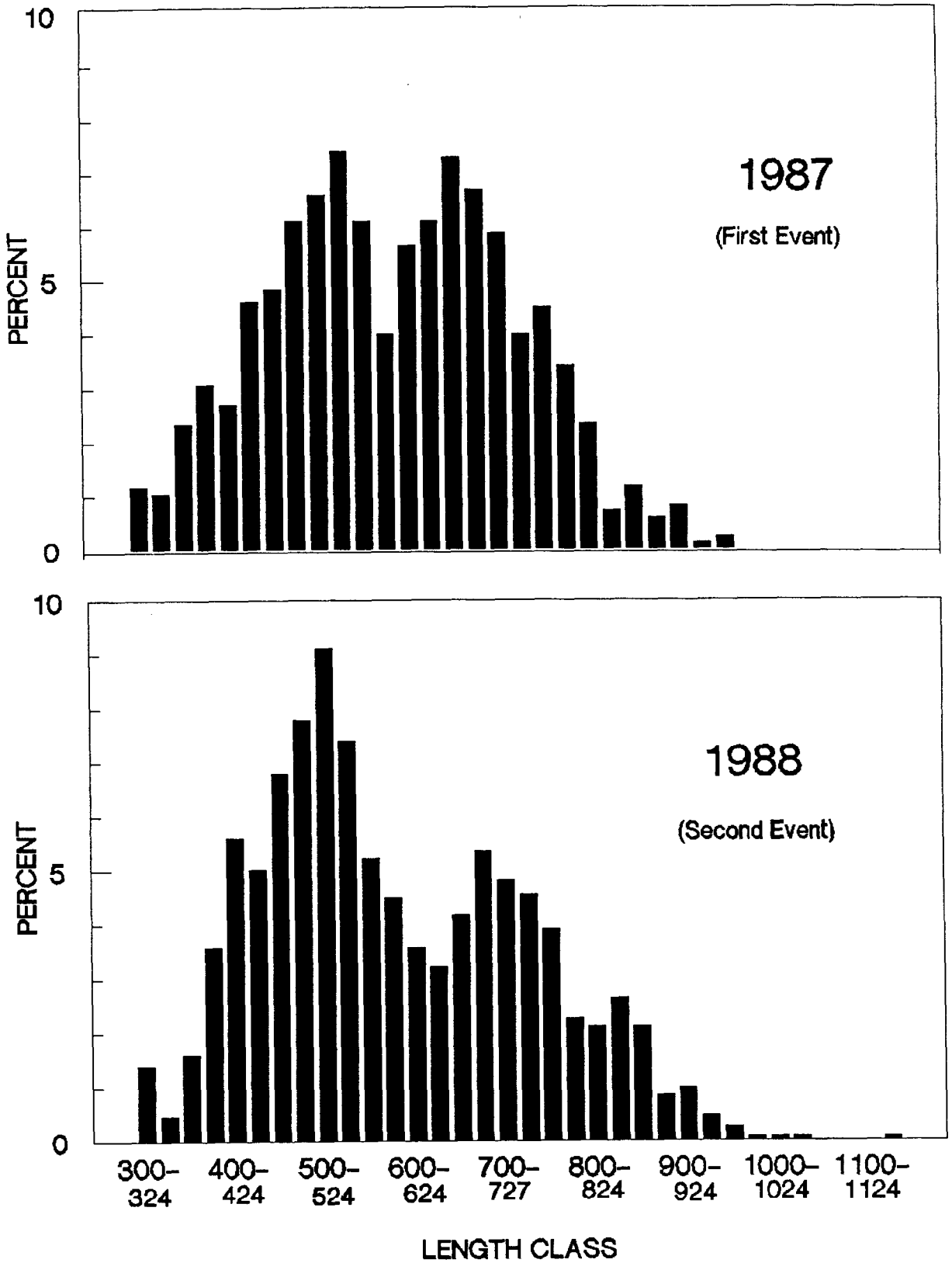

Figure 3. Length frequency of northern pike in Minto Flats for 1987 and 1988.

Table 7. Relative Stock Density (RSD) estimates with abundance estimates of stock, quality, preferred, memorable, and trophy size fish during 1987 and 1988.

		1987				1988			
Category	Gabelhouse Minimum Length	RSD[1]	SE	Abund.	SE	RSD[1]	SE	Abund.	SE
Stock	300 mm	32.90	1.61	7,663	1,788	39.64	3.35	10,353	536
Quality	525 mm	30.55	1.56	7,116	1,664	24.30	1.21	6,346	508
Preferred	655 mm	34.08	1.62	7,940	1,850	31.66	3.39	8,267	1,500
Memorable	860 mm	2.47	0.05	574	178	4.33	0.69	1,131	244
Trophy	1,080 mm					0.07	0.07	18	18
Totals		100.00		23,293		100.00		26,115	

[1] Relative Stock Density expressed as a percentage: categories taken from Gabelhouse (1984).

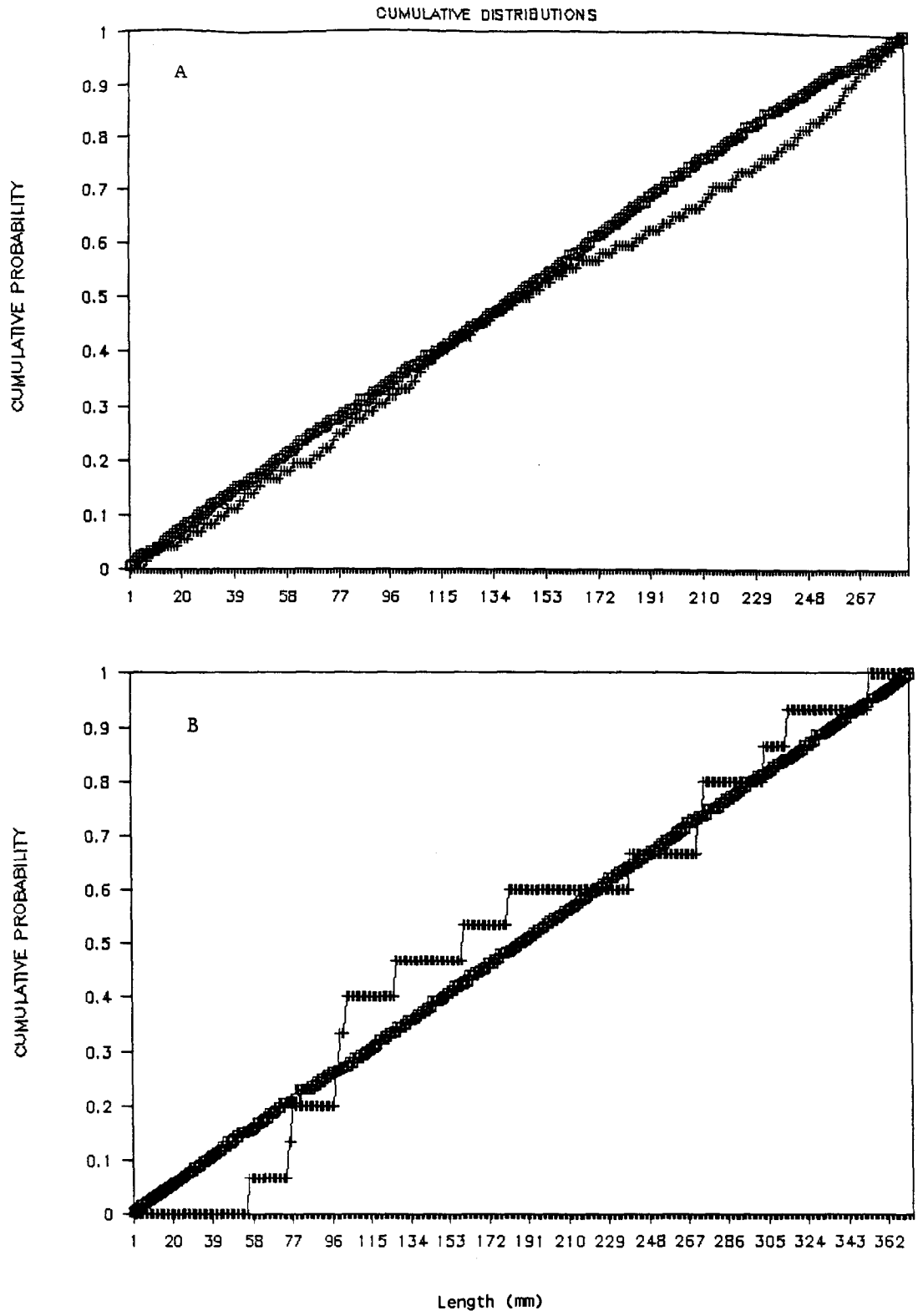

Figure 4. Cumulative probability of length distributions for A: lengths of fish marked in the first event (squares) versus lengths of recaptured fish in the second event (pluses); and B: lengths of all fish captured in the first event (squares) versus lengths of all fish captured in the second event (pluses).

Abundance Estimate 1988

Estimated abundance of northern pike > 299 mm in Minto Flats in the spring of 1988 was 26,115 fish (SE = 2,175). The bias associated with this estimate is approximately 5,000 fish (bootstrap methods of Efron, 1982) due to partial mixing and significantly different probabilities of recapture of fish > 599 mm. Since growth recruitment was detected for fish < 600 mm, two abundance estimates (fish < 600 mm and fish > 599 mm) were conducted. Estimated abundance for northern pike less than 600 mm and greater than 599 mm was 14,637 (SE = 689) and 11,479 (SE = 2,063), respectively.

Lengths of fish in the 300-599 mm category which were marked during the first event and recaptured during the second event were not significantly different (D = 0.20, P = 0.70) indicating no size selectivity in the second event. Size selectivity did occur in the first event. Lengths of all fish which were captured during the first event and during the second event were significantly different (D = 0.09, P = 0.09). Lengths of fish in the > 599 mm category which were marked in the first event and recaptured during the second event were not significantly different (D = 0.11; P = 0.92) indicating no size selectivity in the second event. Size selectivity did occur during the first event. Lengths of fish marked during the first event and caught during the second event were significantly different (D = 0.25: P = 0.00).

For northern pike 300-599 mm, mixing of marked with unmarked fish among Areas I, II, and III between events was not complete but probabilities of capture during the second event were not significantly different (χ^2 = 0.83 df = 2 0.75 < P < 0.50). For northern pike > 599 mm, mixing was not complete between events, and the probabilities of capture during the first event were significantly different (χ^2 = 8.61, df = 2, 0.025 < P < 0.01). In situations of partial mixing and unequal probabilities of capture, the stratified method of Darroch (1961) produces an unbiased estimate of abundance so long as negative capture probabilities are not present in the estimator. This estimator was applied and rejected due to negative capture probablities. Therefore, the Chapman modification of a single-mark Peterson estimator (Chapman 1951: Seber 1982) was employed.

Only a few northern pike were caught during the first sampling event by electrofishing, therefore differential mortality from electrofishing was not taken into consideration for the 1988 abundance estimates.

DISCUSSION

The results of the telemetry, recapture, and ancillary sampling data indicate northern pike use Area I and Area III throughout the entire year, and Area II primarily during the summer. Relative mixing rates of northern pike for Areas I and III show a high degree of fidelity to these respective Areas. Temporal utilization of the three major areas in Minto Flats in concert with fidelity of northern pike to Areas I and III provides evidence to suggest that Minto Flats supports two geographic subpopulations. One subpopulation resides primarily in Area I and the other subpopulation resides primarily in Area III,

with individuals from both subpopulations inhabiting Area II during the summer.

Relative Stock Densities for northern pike populations in Minto Flats and T Lake (Clark 1988) were very similar. Quality and preferred categories comprised about two thirds of both populations. Other Alaskan northern pike populations consisted mostly of stock-sized fish: 74.34% of George Lake (Clark et al. 1988) and 66.0 % of Volkmar Lake (Clark and Gregory 1988).

Clark and Gregory (1988) suggest that differences in Relative Stock Density between T, George, and Volkmar Lakes may be due to differences in fishing pressure. T Lake, which had the lower Relative Stock Density of small fish and the greater density of large fish also experienced the least fishing pressure during 1987. Volkmar Lake, which was intermediate between T and George Lakes, was also intermediate in the amount of fishing pressure, and George Lake, which had the lowest percentage of large fish and the greatest percentage of small fish experienced the highest exploitation rate of the three lakes during 1987 (Timmons and Pearse, In press). This trend does not appear to apply to Minto Flats since the combined sport and subsistence exploitation exceeds sustainable yield (16%) based on limited experience with other stocks of northern pike in the Tanana drainage (Mills 1987; Peckham 1986; Peckham and Bernard 1987).

Tag loss could not be calculated for either the 1987 or 1988 abundance estimates although tag loss did occur. Therefore the reported estimates are biased and are considered to slightly overestimate the abundance of northern pike in Minto Flats for the two time periods. Tag loss of 6% has been reported for a northern pike mark-recapture experiment in George Lake (Clark et al. 1988)

Estimated densities for northern pike in Minto Flats for 1987 and 1988 (3.87 and 4.35 fish over 299 mm FL per ha, respectively) were in the low end of the range reported for other Alaskan northern pike populations. The density of northern pike over 299 mm FL in 1987 for Volkmar Lake was estimated to be 25.6 fish per ha (Clark and Gregory 1988), 9.69 fish per ha for George Lake (Clark et al. 1988) and 3.85 fish per ha for T Lake (Clark 1987).

Estimated densities for northern pike in Minto Flats were also at the low end of the range of densities reported for various non-Alaskan populations. Average density for northern pike over 400 mm total length (TL) in Savanne Lake, Ontario, in 1973, 1977, and 1988 was estimated at 6.66 fish per ha with a range of 5.91 to 7.19 fish per ha (Mosindy and Momot 1987). Mann (1980) estimated average density of age 1 and older northern pike in the Stour River, England, to be 61 fish per ha over a 5 year period (range 27 to 127 fish per ha). Mann (1980) also reported a density range of 32 to 80 age 1 and older northern pike per ha in the Frome River, England. Seaburg and Moyle (1964) estimated the density of northern pike over 250 mm TL in Grove Lake, Minnesota, at 7.6 fish per ha and the density of northern pike over 355 TL in Maple Lake, Minnesota at 4.8 fish per ha. Over a series of years, the density of northern pike over 356 mm TL in Murphy Flowage, Wisconsin, was estimated by Snow (1978) to range from 5.8 to 40.6 fish per ha (mean = 20.8 fish per ha). Kempinger and Carline (1978) estimated density of northern pike in Escanaba

Lake, Wisconsin, over a series of years, and they reported a mean density of 6.9 fish per ha for age 1 and above fish and a mean of 0.9 fish per ha for fish over 560 mm TL.

Limited experience with stocks of northern pike in the Tanana River drainage has shown that annual yields of 16% from a stable population are sustainable based on estimates of abundance and harvest of northern pike from Volkmar Lake (Mills 1987; Peckham 1986; Peckham and Bernard 1987).

The estimated combined sport (Mills 1988) and subsistance (Andrews 1988) northern pike harvest in 1987 (subsistence harvest is estimated at approximately 3,000 fish per year) was 4,715, accounting for at least 19% of the estimated 1987 northern pike population. Using 16% as a guideline for maximum sustainable yield (MSY), the 1987 northern pike harvest in Minto Flats exceeded MSY.

With the closure of the winter sport fishery in 1987 the sport harvest dropped from 4,903 (Mills 1987) in 1986 to 1,715 (Mills 1988) in 1987. In the spring of 1988 the Board of Fisheries adopted a regulation to reduced the bag limit to five northern pike a day with one fish over thirty inches. The results of this new regulation on sport harvest in Minto Flats are not available at this time.

If the current regulations fail to reduce the sport harvest and the abundance of northern pike remain at or below current levels, more restrictive regulations or closure of the sport fishery will need to be considered.

Future investigations will be focused at determining whether or not the two geographic sub-populations of northern pike in Minto Flats are seperate stocks. The abundance estimates of each sub-population will also need to be estimated in the future.

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APPENDIX

Appendix Table 1. Applications of a nonparametric test[1] for growth recruitment between sampling events in Minto Flats during 1988[2].

							Logarithms of Factorials of the Expressions Below					
L(i)	u(i)	n	c	c+n-u(i)	c-u(i)	c+n	c	c+n-u(i)	c-u(i)	c+n	P[c>u(i)]	
368	41	34	1422	1415	1381	1456	8906.01	8855.21	8608.94	9153.26	0.37	
429	149	33	1381	1265	1232	1414	8608.94	7775.17	7539.87	8847.95	0.02	3
451	74	32	1232	1190	1158	1264	7539.87	7241.69	7015.50	7768.02	0.14	
455	20	31	1158	1169	1138	1189	7015.50	7093.15	6874.57	7234.61	0.59	
495	168	30	1138	1000	970	1168	6874.57	5912.13	5705.33	7086.09	0.01	3
511	91	29	970	908	879	999	5705.33	5280.93	5083.86	5905.22	0.06	3
516	25	28	879	882	854	907	5083.86	5104.20	4914.74	5274.12	0.45	
533	67	27	854	814	787	881	4914.74	4645.67	4465.15	5097.42	0.11	
535	12	26	787	801	775	813	4465.15	4558.64	4385.21	4638.96	0.68	
538	12	25	775	788	763	800	4385.21	4471.82	4305.47	4551.95	0.68	
558	85	24	763	702	678	787	4305.47	3903.06	3746.16	4465.15	0.06	3
605	114	23	678	587	564	701	3746.16	3159.25	3013.06	3896.50	0.02	3
607	3	22	564	583	561	586	3013.06	3133.76	2994.06	3152.87	0.89	
613	12	21	561	570	549	582	2994.06	3051.10	2918.22	3127.39	0.64	
620	13	20	549	556	536	569	2918.22	2962.43	2836.36	3044.76	0.62	
624	9	19	536	546	527	555	2836.36	2899.30	2779.87	2956.11	0.73	
634	15	18	527	530	512	545	2779.87	2798.68	2686.06	2893.00	0.60	
645	25	17	512	504	487	529	2686.06	2636.21	2530.70	2792.41	0.43	
650	11	16	487	492	476	503	2530.70	2561.67	2462.74	2629.99	0.70	
659	11	15	476	480	465	491	2462.74	2487.42	2395.04	2555.47	0.71	
662	12	14	465	467	453	479	2395.04	2407.33	2321.48	2481.25	0.70	
666	12	13	453	454	441	466	2321.48	2327.59	2248.23	2401.18	0.71	
670	11	12	441	442	430	453	2248.23	2254.32	2181.38	2321.48	0.74	
690	59	11	430	382	371	441	2181.38	1893.04	1827.79	2248.23	0.20	
692	3	10	371	378	368	381	1827.79	1869.28	1810.05	1887.10	0.92	
693	6	9	368	371	362	377	1810.05	1827.79	1774.64	1863.34	0.86	
695	7	8	362	363	355	370	1774.64	1780.53	1733.46	1821.87	0.86	
725	86	7	355	276	269	362	1733.46	1278.96	1239.69	1774.64	0.15	
768	111	6	269	164	158	275	1239.69	675.85	645.34	1273.34	0.04	3
780	22	5	158	141	136	163	645.34	560.17	535.50	670.75	0.48	
801	22	4	136	118	114	140	535.50	448.25	429.21	555.22	0.50	
815	15	3	114	102	99	117	429.21	372.98	359.13	443.47	0.66	
820	7	2	99	94	92	101	359.13	336.26	327.18	368.35	0.87	
905	92	1	92	1	0	93	327.18	-	-	331.72	-	

[1] Robson and Flick 1965.

[2] L(i) is the ith length in m+1, ordered, unique lengths of fish;
u(i) is the number of unmarked fish with lengths that fall between L(i) and L(i-1);
c is the sum of the u(i) from i to M+1;
n is M+1-i (M is the number of marked fish in the sample); and,
P[c>u(i)] is the probability of a Type I error.

[3] Significant at P = 0.10.